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Description

The invention relates to a heat transfer surface comprising a number of elongated cells which are independent of and parallel with each other to extend along an outer surface layer and which communicate with the outside of the heat transfer surface through restricted holes formed in each of the cells.

The prior art according to the GB—A—574 949 describes a plate heat exchanger apparatus for a mono-flow of material such as oil, water and air. Flow passages which are used to heat-exchange with each other are alternately laminated with each other. Therefore, the respective flow passages are not communicated with each other, and the dimension of each of the passages must be large above 1 cm.

There have been heretofore proposed a number of techniques as to a heat transfer surface for enhancing boiling or evaporating heat transfer.

It has been proposed to roughen the heat transfer surface by sintering, radiation-melting or edging methods to form a porous layer thereon. The wall having such a porous layer is known to exhibit better heat transfer characteristic than that of a conventional planar wall. However, in such a porous layer, since voids or cells formed therein are small, impurities contained in boiling liquid or non-boiling liquid contained therein will enter into the voids or cells to clog them so that the heat transfer performance of the wall will be degraded. Also, since the voids or cells formed in the porous layer are non-uniform in size or dimension, the heat transfer performance is locally changed.

On the other hand, as shown in US—A—4,060,125, there has been known a heat exchange wall having a number of tunnels or voids formed under its surface layer and a number of openings allowing the tunnels or voids to open to the outside of the heat transfer surface. Such a heat transfer surface possesses a high heat transfer performance. The openings are larger in size than those of the porous layer obtained through the sintering method, and in the wall having the tunnels and openings a possible degradation in performance due to clogging of impurity, non-boiling liquid and the like is small.

However, the heat transfer surface having the tunnels or voids and the opening requires an optimum openings diameter in compliance with a thermal load imposed to the heat transfer surface. Therefore, when the thermal load is excessively small or large, its heat transfer performance will be degraded.

The object of the invention is to provide a heat transfer surface having a structure capable of effectively achieving the phase-conversion of liquid with a high heat transfer performance which is stable.

This object is obtained according to the invention in that at least two layers of groups of cells are laminated in a direction normal to the heat transfer surface and in that the groups of cells communicate with each other through restricted holes formed in the partition wall between each of the cells.

It is preferred that the cross-sectional areas of the respective holes are smaller than a maximum value of cross-sectional area of the cells disposed under the respective holes.

Advantageously, an inner surface of each of the cells is roughened.

It is convenient that the cell groups include cells having a susbstantially constant configuration and are arranged in a regular manner, and holes having a substantially constant configuration.

The holes may be comprised of first and second hole groups which have maximum cross-sectional areas different from each other.

The surface structure of the heat transfer surface according to the invention promotes the heat exchange of two-phase flows, i.e. boiling or evaporation, and the representation dimension is very small below 1 mm or less.

The layers in accordance with the invention, i.e. the flow passages in form of elongated cells in the adjacent layers in the normal or vertical direction with respect to the heat transfer wall surface communicate with each other. Also, in accordance with the present invention, the cells in the outermost cell group are communicating with the outside of the heat transfer wall so that the evaporation may be charged into or discharged from the cell group in the outermost layer.

Incidentally, the heat transfer surface having the laminate structure of the invention may be made of material as in or different from the material constituting the outer portion constituting member of the heat transfer surface base member. For example, in the case where corrosive liquid will flow on the underside surface of the base material of the heat transfer surface of the invention, the anti-corrosive material is selected and used as the base member. However, the anti-corrosive material is, generally, difficult to be machined and is expensive. However, on the other hand, since material which is easy to be machined and is inexpensive may be selected as the heat transfer surface outer material, in comparison with the conventional heat transfer surface formed integrally, the heat transfer surface in according with the invention has a remarkable advantage in industrial aspect.

As has been apparent from the foregoing description according to the invention, there are provided laminated cells and hole structures to the heat transfer surface, so that it is capable of carrying out the heat transfer under the optimum condition of the respective layer cells. For this reason, the heat transfer surface offers a high performance and uniform ability against the heat load in a wide range. Furthermore, according to the invention, stable heat transfer surface may readily be produced.

By means of drawings embodiments of the invention are further explained.

Figs. 1 and 2 are perspective views, fragmentary in part, of heat transfer walls in accordance

with embodiments of the invention;

Fig. 3 is a perspective view, fragmentary in part, of a thin plate portion for illustrating a method of manufacturing the walls shown in Figs. 1 and 2;

Figs. 4 to 7 are cross-sectional views illustrating the operations of the embodiments;

Figs. 8 and 9 are perspective views showing other embodiments of the invention;

Figs. 10 and 11 are views showing other examples of thin plates in accordance with the invention;

Figs. 12 to 15 are views showing other embodiments of the invention and their manufacturing method;

Figs. 16 to 18 are views showing other embodiments of the invention and their manufacturing method;

Figs. 19 and 20 are views showing still other embodiments of boiling heat transfer walls in accordance with the invention; and

Fig. 21 is a graph showing a comparison result in heat transfer performance between the invention and the prior art.

Reference will now be made to the embodiment shown in Fig. 1. A multiplicity of elongated groove-like void or cell groups 12 (12a, 12b) are provided in parallel on an outer surface layer 11 of a heat transfer wall to form two layers. In a partitioning wall 13 between the two layers of voids or cells 12a, 12b, there are formed a multiplicity of holes 14 having cross sections smaller than maximum cross sections of the lower layer of voids or cells 12b for allowing the two layers of voids or cells 12a, 12b to communicate with each other. The holes 14 are formed at a certain interval along the lower layer of cells 12b. Also, in a ceiling wall 15 of the upper layer of voids 12a, there are formed a multiplicity of holes 16 having cross sections smaller than maximum cross sections of the upper layer of voids or cells 12a for allowing the upper layer of voids or cells 12a and the outside of the heat transfer wall to communicate with each other. The holes 16 are formed at a certain interval along the upper layer of cells 12a. Thus, by the holes 14, 16, the uppere and lower layers of cells 12a, 12b and the outside of the heat transfer wall are communicated with one another. The intervals and sizes of the holes 14, 16 may be arbitrarily selected. It is understood that configurations of cross sections of the cells 12a, 12b and configurations of cross sections of the holes 14, 16 are not necessarily limited to those shown in the embodiment. Those factors may be suitably selected from circular, polygonal, rectangular and oblong shapes, as desired. However, in any case, the maximum value of the cross-sectional area of the cells 12a, 12b must be greater than the cross-sectional area of the respective holes 14, 16.

In the above-described structure, it is preferable to select a diameter d of the holes 14, 16 in a range of about 0.05 to 1.0 mm, a hole area ratio in a range of 0.01 to 0.3 and a hole pitch or interval in a range of about 1 to 20 holes/cm, respectively.

On the other hand, a capillary effect of the cells depends upon a width B and a height H of the cross section of the cells 12a, 12b. When the width B and the height H are too small, an entraining effect of liquid in the cells will be excessively large. Inversely, when the width B and the height H are too large, the capillary effect will become insufficient. In either case, a heat transfer will be adversely effected. In practical use, both the width B and the height H require 0.15 mm or more. Also, the cell pitch or interval is preferably selected from a range of about 1 to 20 cells/cm.

In an embodiment shown in Fig. 2, the upper and lower layers of cells 12a, 12b are intersected with each other at a predetermined angle. The other structural features are the same as those in the embodiment shown in Fig. 1.

The heat transfer walls shown in Figs. 1 and 2 may readily be manufactured as described below. As shown in Fig. 3, a thin planar plate 100 to form an outer surface of the heat transfer wall is provided with a multiplicity of elongated grooves 102 through a mechanical cutting-machining or a plastic machining such as a groove knurling. Holes 103 passing through the thin plate are formed in bottoms of the thus formed grooves at a predetermined interval. The holes 103 may be formed simultaneously with the formation of the groove-machining of the thin plate 100. The formation of the grooves 102 and the holes 103 may be carried out by well known processes such as chemical etching, laser beam machining and electronic beam machining. Two or more thin plates 100 having the multiplicity of grooves 102 and holes 103 are laminated on one another and are brought into intimate contact with or cemented on the base suface of the heat transfer wall, thereby forming a heat transfer surface structure according to the invention. If upon laminating, the grooves 102 of the upper and lower layers are arranged in parallel to each other in order not to clog the holes 103 of the thin plates 100, the wall shown in Fig. 1 may be produced. Also, the grooves 102 of the upper and lower thin plates are intersected with each other to form the heat transfer wall shown in Fig. 2.

In the embodiment shown in Fig. 1, if the upper and lower thin plates would be displaced with each other, there is a fear that the partitioning wall 13 of the upper and lower layers of cells would be damaged. However, in the embodiment shown in Fig. 2, even in such an occasion, the partitioning wall 13 between the upper and lower layers would not be damaged.

The operation and effect of the above-described embodiments will now be described in detail.

When the heat transfer surface is heated at a temperature higher than that of boiling liquid in contact with the surface as shown in Figs. 4 and 5, evaporation bubbles 30 are generated in and occupies the cells 12a, 12b of the upper and lower layers. Then, when a pressure of vapor within the cells 12b of the lower layer is higher than that within the cells 12a of the upper layer, a part of the evaporation bubbles 30 will be discharged through the restricted holes 14 of the partitioning wall 13 to the cells 12a of the upper layer. The

remainder of the bubbles is left in the cells 12b of the lower layer as residual evaporation bubbles. The cells 12a of the upper layer, on the other hand, receives the discharge of vapor from the voids or cells 12b of the lower layer, and new vapor will be generated by heats of the cells 12a *per se*. Accordingly, a pressure within the cells 12a of the upper layer will be higher than that of outside liquid 50. Then, the vapor retained in the cells 12a of the upper layer will be discharged from the restricted holes 16 of the ceiling wall 15 to the outside as a separating bubbles 40. The remainder of vapor are retained in the cells 12a of the upper layer as residual vapor bubbles. The pressure in the cells is higher than that of the liquid 50 existing outside of the heat transfer wall and is gradually increased from the upper layer to the lower layer. In accordance with the discharge of the vapor from the cells 12a, 12b, the pressure within the respective cells 12a, 12b is changed whereupon liquid enters into the cells 12a, 12b. The outside liquid 50 enters into the cells 12a of the upper layer whereas a part of the entering liquid in the cells 12a enters into the cells 12b of the lower layer 12b. Accordingly, in the cells 12b in the lower layer, the pressure therein is kept at a higher level, and since the liquid to enter thereinto has passed through the cells 12a of the upper layer, a part of the liquid is heated and the amount thereof is restricted to a lower level. For this reason, even at a lower thermal load, the amount of the liquid 50 in the cells 12b is small, and in addition, since the liquid film sprayed or diffused on the inner walls of the cells 12b is thin, it is possible to generate vapor by a small degree of heat. In other word, at a lower heat load, the cells 12b of the lower layer is more available to enhance the heat transfer performance than the cells 12a of the upper layer, thereby increasing the heat transfer coefficient as a whole. It should be noted that when the width B and the height H of the cells are too small, a great amount of liquid is entrained into the cells 12b of the lower layer by the capillary force, resulting in restriction to the generation of vapor.

On the other hand, at a higher heat load, as shown in Figs. 6 and 7, vapor 60 is filled in the cells 12a of the lower layer, liquid 50 is difficult to enter into the cells 12a, and a dry condition is kept. However, since the invasion of the liquid is more easily achieved in the cells 12a of the upper layer than in the cells 12b of the lower layer, the cells 12a of the upper layer is hardly under the dry condition. If the size of the holes 16 for the upper layer is selected to a sufficiently large size, even at the higher heat load, it is possible to keep the heat transfer performance at a higher level only with the cells 12a of the upper layer.

Accordingly, with the heat transfer surface according to the invention, the cells 12b of the lower layer act effectively at a lower thermal load whereas the cells 12a of the upper layer act effectively at a higher thermal load. Thus, the cells of the two layers act cooperatively against the respective thermal loads. It is of course possible to form three layers of cells but it is satisfactorily available to form two layers of cells. The size of the holes for the upper layer may be large and the size of the holes for the lower layer may be small.

It is also available that a volume of the cells of the upper layer is large and a volume of the cells of the lower layer is small. For instance, this is attained by rendering a height of the cells 12a of the upper layer greater than that of the cells 12b of the lower layer. Otherwise, as shown in Fig. 8, it is sufficient that a transverse width of the cells 12 of the upper layer is kept large and is twice the pitch of the cells 12' of the lower layer, the other constructions are made unchanged. Incidentally, as in the structure shown in Fig. 2, if the cells belonging to the upper and lower layers are intersected with each other. it is possible to select an arbitrary value as the pitch of the cells of the upper layer with respect to the pitch of the cells of the lower layer. In any embodiment described above, at a higher thermal load, the outside liquid may be sufficiently entered into the cells of the upper layer so that the dry condition hardly occurs. Also, at a lower thermal load, the amount of liquid to enter into the cells of the lower layer is restricted, so that the thickness of the liquid film in the cells of the lower layer and the heat transfer performance is much more enhanced than in the embodiments shown in Figs. 1 and 2.

In an embodiment shown in Fig. 9, an inner wall constituting member for the cells of the upper layer is arranged so as to intersect with the groove-like cells of the lower layer, whereby restricted holes may be formed with respect to the maximum cross section of the cells of the lower layer.

In the case of the embodiment shown in Fig. 9, a multiplicity of elongated parallel grooves 18 are, in advance, formed on an outer surface of the base member 11 of the heat transfer wall. Thereafter, the thin plate 100 having a number of grooves 102 and holes 103 as illustrated in Fig. 3 is cemented on or brought into intimate contact with the base member 11 of the heat transfer wall so that the grooves 102 of the thin plate 100 and the grooves 18 of the base member 11 intersect with each other and confront each other, thereby forming the heat transfer wall shown in Fig. 9. In this case, the grooves 102 of the thin plate serve as the cells 12a of the upper layer and the grooves 18 of the base member 11 serve as the cells 12b of the lower layer. Each ridge 17 between the grooves 102 of the thin plate is adapted to partially cover the grooves 18 of the lower layer so that a plurality of rectangular holes 19 having cross sections smaller than the maximum cross-sectional area of the cells of the lower layer.

In any of the above-described embodiments, explanation has not been especially made as to a surface condition of the inner wall of cells. However, it is to be noted that if the inner wall surface is rougher than a planar smooth surface, the inner wall surface of cells tends to be wet with respect to the liquid and the liquid film may readily be spread or diffused. For this reason, the thickness

of the liquid film formed on the inner wall surface of cells becomes thin and its heat transfer characteristic is much more enhanced than on the planar smooth surface. The surface roughness is preferably R_p = 0.0005 to 0.002 cm.

In embodiments shown in Figs. 10 and 11, the thin plate 100 is provided with holes by rolling, knurling or die-machining, and the holes 103 are formed by punching or cutting. As a result, upon the formation of holes, barrier projections are formed on a surface opposite to the groove forming surace of the thin plate 100. For this reason, when a number of thin plate 100 having grooves and holes are laid one on another in a laminate fashion, the aligning work of the holes 103 of the lower layer and the grooves 102 of the upper layer may be facilitated. For example, a multiplicity of projections are formed at a tip end of a tooth of grooving roll and a recess is formed on the associated plain roll in alignment with the projections whereby a thin plate is clamped between the two rolls and the rolls are pressingly rotated, so that the groove-forming and the hole-forming may be simultaneously carried out.

Another embodiment of the invention will be described with reference to Figs. 12 to 15. In a first process, shallow recesses 21 are formed on an outer surface 20 of a circular tube by knurling. The recesses are arranged in a direction forming an angle of about 45° with respect to the tube axis. Subsequently, in a second process, grooves and crests are formed in a direction perpendicular to the tube axis by using bites. A height of fins 22 formed through the above-described process is about 1 mm and is greater than that of the recesses 21 formed through the first process. According to this method, rows of the fins 22 having concave and convex portions as shown in Fig. 12 are formed. In a third process, a thin wire 24 having in its outer surface minute grooves 23 as shown in Fig. 13 is wound in the groove formed between the fins 22 to thereby offer a state shown in Fig. 14. Cells 12b are formed between the thin wire 24 and the fins 22 and the minute grooves 23 formed in the wire 24 serve as the holes. Incidentally, even if the thin wire 24 having no minute grooves 23 is wound in the grooves, there would be a possibility that a gap would be formed at contact portions between the thin wire and fins. However, it is preferable to form the minute grooves in the thin wire to ensure the formation of the holes. In a fourth process, tip ends of the fins 22 are bent as shown in Fig. 15 by rolling or brushing. The adjacent fins are brought into contact with each other whereby the cells 12a are formed. Then, the shallow recesses formed through the first process serve as the holes 16.

In still another embodiment shown in Fig. 16, a multiplicity of elongated parallel grooves 202 having a minute dimension are formed on an elongated tape-like thin plate 200 forming an outer layer of the heat transfer wall. The above-described grooves 202 are manufactured through a machining method such as cutting or groove-forming, a plastic machining such as rolling or pressing or a molding method such as casting. The holes 14' are larger than the holes 14 in size.

The selection of the forming methods described above depends upon the material constituting the thin plate 200. For example, the rolling process is available for material having an excellent ductility, such as copper, and the moulding process is available for fragile material such as ceramics. In any of the processes, additional parts 204 are formed, in groove end portions at the same pitch as the grooves, at end faces of the tape-like thin plate 200. It should be noted that in the embodiment shown in Fig. 16, the structure is formed by rolling and is rolled by a fine pitch gear of involute gear shape and a plain roll in combination.

The above described elongated tape-like thin plate 200 shown in Fig. 16 are arranged regularly on the base member 11 of the heat transfer wall with the above-described grooves 202 being directed downwardly as shown in Fig. 17. In this case, the cells 12a just under the outer surface are formed by the grooves 202 and the base material 11 of the heat transfer wall and the holes 14, 14' are formed by the additional part 204, 204'' formed at the end face of the tape-like thin plate 200 and the end face of the other tape-like thin plate 200', 200'' adjacent to the thin plate 200.

Subsequently as shown in Fig. 18, the elongated tape-like thin plates 200a, 200b are laid on the base member 11 of the heat transfer wall to form two layers. With such a heat transfer surface the combination of the cells and holes is also forming the upper and lower layers. Accordingly, the cells 12b are communicated with the cells 12a of the upper layer through the holes 14, 14' and the cells 12a of the upper layer is communicated with the outside boiling liquid through the holes 16, 16' for the upper layer.

Still another embodiment of the invention will now be described with reference to Fig. 19.

In the outer portion of the heat transfer wall 11, there are provided a multiplicity of elongated tunnel-like cells 12a, 12b forming double wall structure in parallel to each other. The inside cells 12b are partitioned from the outside cells 12a by smaller fins 302, and are communicated with the outside cells 12a through holes 14 formed between the smaller fins 302 and larger fins 300. The outer cells 12a are communicated with the outside of the heat transfer wall 11 through holes 16 formed at the adjacent fins 300'. On the other hand, the fins 300 and 302 are raised so that the cross sections of the above described holes 14, 16 are smaller than those of the cells 12b, 12a, respectively. The tip ends of the fins 300, 302 are not shaped in an aligned form such as a knife edge as shown in Fig. 19 according to the characteristics of metal material, and in those of curved, cracked, entrained or other irregular ends.

In another embodiment shown in Fig. 20, inside fins 306 are formed in the midway of the outer fins 304, and parts of the outer fins 304 are projected outside of the heat transfer wall 11. The other constructions are the same as in the em-

bodiment shown in Fig. 19.

To testify the heat transfer ability of the heat transfer surface according to the invention, a boiling heat transfer experiment was carried out at an atmospheric pressure in accordance with the heat transfer surface shown in Fig. 1. A used boiling coolant liquid was $CFCl_3$ (Freon R—11). The heat transfer surface was made of copper. The same dimension was selected for the cells of the two layers, the cell pitch was 0.55 mm, the width B of the cells in cross section was 0.25 mm, the height H thereof was 0.4 mm, the hole pitch was 0.7 mm and the diameter of the holes was 0.25 mm. The heat transfer performance A is shown in Fig. 21. Also, in Fig. 2, there is shown the heat transfer performance B of the single layer type heat transfer surface, having the same cells and dimensions as those of the surface of the invention, the comparison surface being proposed in U.S.—A—4,060,125. The abscissa represent a heat flux a (W/m^2) of the standard or reference projection area of the heat transfer surface and the ordinate represent a heat transfer coefficient α ($W/K{\cdot}m^2$) of the reference projection area.

The heat transfer surface A according to the invention exhibited a high heat transfer coefficient exceeding the simple increasing degree (twice) of effective heat transfer area at the normal heat flux range ($5 \times 10^3 - 3 \times 10^4$ W/m^2) of the heat transfer surface in comparison with the prior art heat transfer surface B. In particular, the heat transfer coefficient of the invention reached a value three times larger than that of the prior art in the smaller range of the heat flux q. Also, according to the invention, over the whole heat flux range, the heat transfer coefficient was higher than that of the prior art heat transfer surface B and kept substantially constant heat transfer coefficient.

Claims

1. A heat transfer surface comprising a number of elongated cells which are independent of and parallel with each other to extend along an outer surface layer (11) and which communicate with the outside of the heat transfer surface through restricted holes (16) formed in each of the cells, characterized in that at least two layers of groups of cells (12a, 12b) are laminated in a direction normal to the heat transfer surface and in that the groups of cells communicate with each other through restricted holes (14) formed in the partition wall (13) between each of the cells.

2. The heat transfer surface according to claim 1, characterized in that the cross-sectional areas of the respective holes (16, 14) are smaller than a maximum value of cross-sectional area of the cells (12a, 12b) disposed under the respective holes (16, 14).

3. The heat transfer surface according to claim 1 or 2, characterized in that an inner surface of each of the cells (12a, 12b) is roughened.

4. The heat transfer surface according to one of the claims 1 to 3, characterized in that said cells (12a, 12b) have a substantially constant configuration and are arranged in a regular manner, and said holes (16, 14) also have a substantially constant configuration.

5. The heat transfer surface according to one of the claims 1 to 4, characterized in that said holes (16, 14) are comprised of first and second hole groups which have maximum cross-sectional areas different from each other.

Patentansprüche

1. Wärmeübertragungsoberfläche mit einer Anzahl von langgestreckten Zellen, die sich unabhängig voneinander und parallel zueinander längs einer äußeren Oberflächenschicht (11) erstrecken und die mit der Außenseite der Wärmeübertragungsoberfläche über verengte Löcher (16) in Verbindung stehen, die in jeder der Zellen ausgebildet sind, dadurch gekennzeichnet, daß wenigstens zwei Schichten von Gruppen von Zellen (12a, 12b) schichtförmig in einer Richtung senkrecht zur Wärmeübertragungsoberfläche angeordnet sind und daß die Gruppen von Zellen miteinander durch verengte Löcher (14) in Verbindung stehen, die in der Trennwand (13) zwischen jeder der Zellen ausgebilet sind.

2. Wärmeübertragungsoberfläche nach Anspruch 1, dadurch gekennzeichnet, daß die Querschnittsflächen der jeweiligen Löcher (16, 14) kleiner als ein Maximalwert einer Querschnittsfläche der Zellen (12a, 12b) sind, die unter den jeweiligen Löchern (16, 14) angeordnet sind.

3. Wärmeübertragungsoberfläche nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß eine innere Oberfläche jeder der Zellen (12a, 12b) aufgerauht ist.

4. Wärmeübertragungsoberfläche nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß die Zellen (12a, 12b) eine im wesentlichen gleichbleibende Gestalt haben und in regelmäßiger Weise angeordnet sind, und daß die Löcher (16, 14) ebenfalls eine im wesentlichen gleichbleibende Gestalt aufweisen.

5. Wärmeübertragungsoberfläche nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß die Löcher (16, 14) von einer ersten und einer zweiten Löchergruppe gebildet werden, die maximale Querschnittsflächen haben, welche voneinander verschieden sind.

Revendications

1. Surface de transfert thermique comportant un certain nombre de cellules allongées qui sont indépendantes les unes des autres et sont parallèles entre elles de manière à s'étendre le long d'une couche superficielle extérieure (11) et qui communiquent avec l'extérieur de la surface de transfert thermique par l'intermédiaire de trous rétrécis (16) formés dans chacune des cellules, caractérisée en ce qu'au moins deux couches de groupes de cellules (12a, 12b) sont superposées suivant une direction perpendiculaire à la surface

de transfert thermique et que les groupes de cellules communiquent les uns avec les autres par l'intermédiaire de trous rétrécis (14) formés dans la cloison de séparation (13) s'étendant entre les différentes cellules.

2. Surface de transfert thermique selon la revendication 1, caractérisée en ce que les surfaces en coupe transversale des trous respectifs (16, 14) sont inférieures à la valeur maximale de la surface en coupe transversale des cellules (12a, 12b) disposées au-dessous des trous respectifs (16, 14).

3. Surface de transfert thermique selon la revendication 1 ou 2, caractérisée en ce qu'une surface intérieur de chacune des cellules (12a, 12b) est rugueuse.

4. Surface de transfert thermique selon l'un des revendications 1 à 3, caractérisée en ce que lesdites cellules (12a, 12b) possèdent une configuration sensiblement constante et sont rangées d'une manière régulière, et que lesdits trous (16, 14) possèdent également une configuration sensiblement constante.

5. Surface de transfert thermique selon l'une des revendications 1 à 4, caractérisée en ce que lesdits trous (16, 14) sont constitué par un premier et un second groupes de trous, qui possèdent des surfaces maximales en coupe transversale, qui diffèrent les unes des autres.

FIG. 1

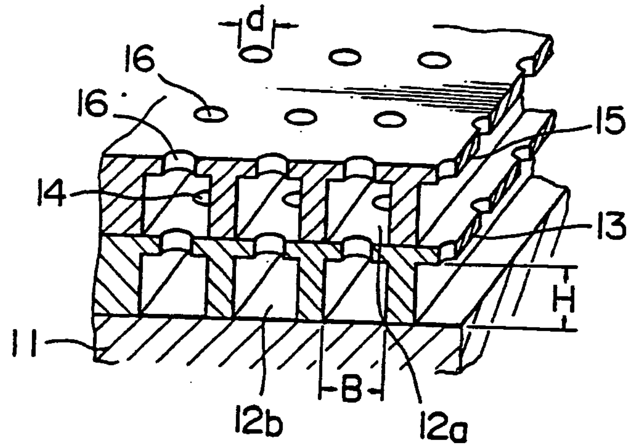


FIG. 2

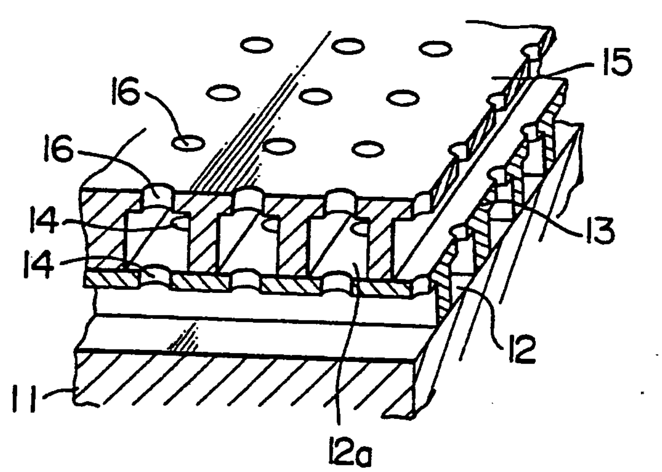


FIG.3

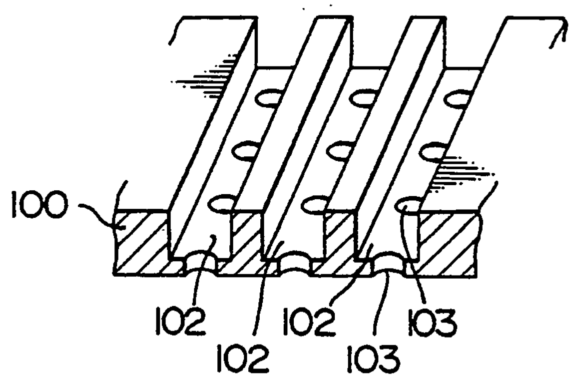


FIG.4

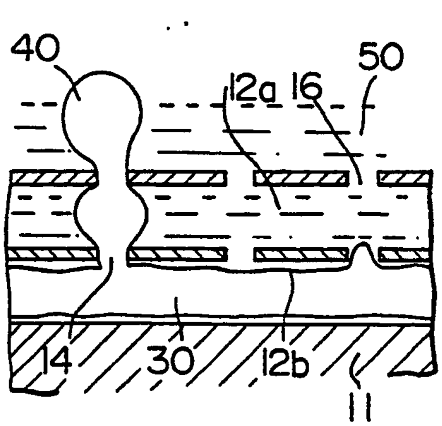


FIG 5

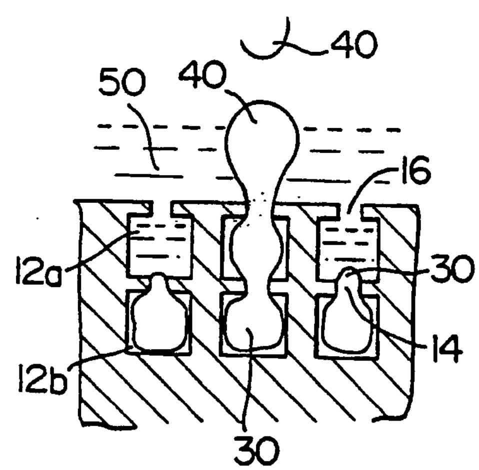


FIG.6

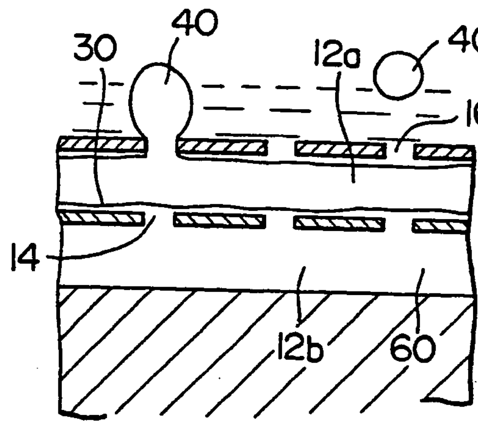


FIG.7

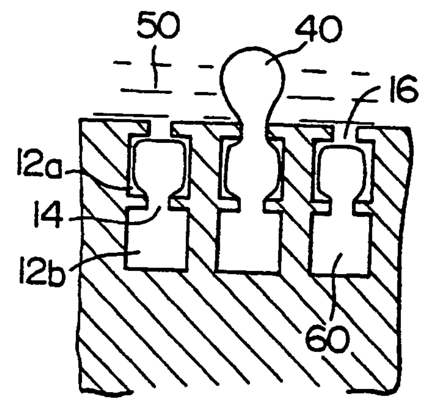


FIG.8

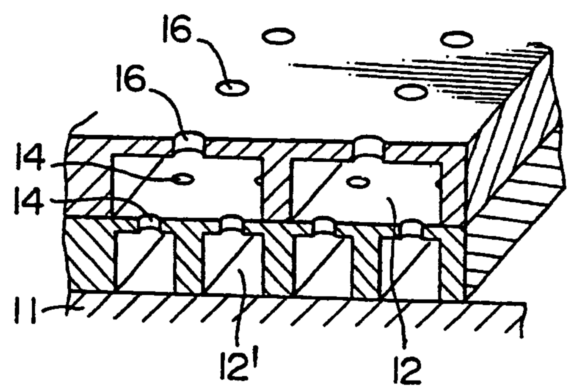


FIG.9

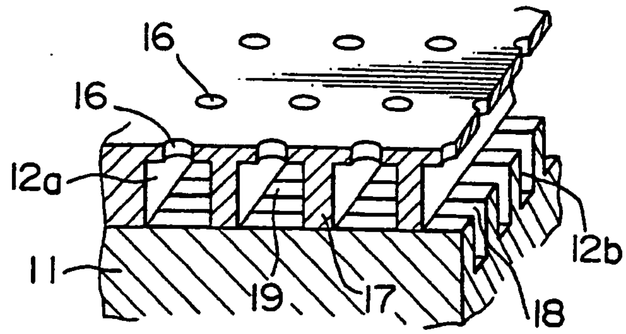


FIG.10

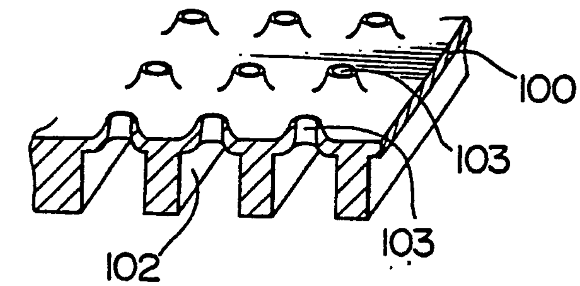


FIG.11

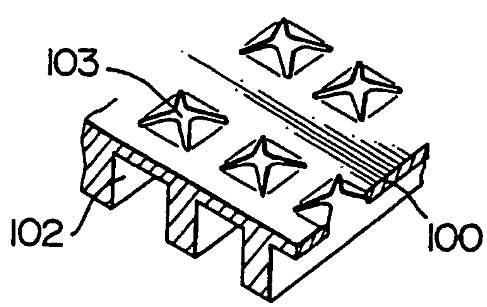


FIG. 12

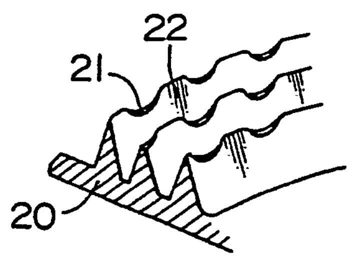


FIG. 13

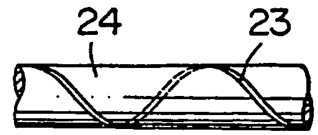


FIG. 14

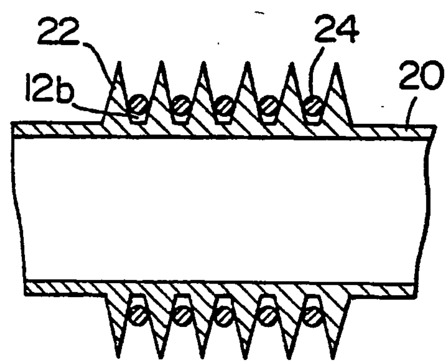


FIG. 15

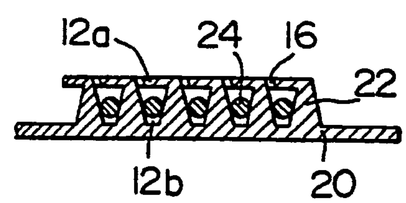


FIG. 16

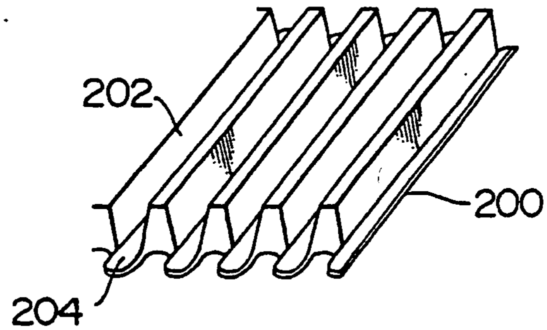


FIG. 17

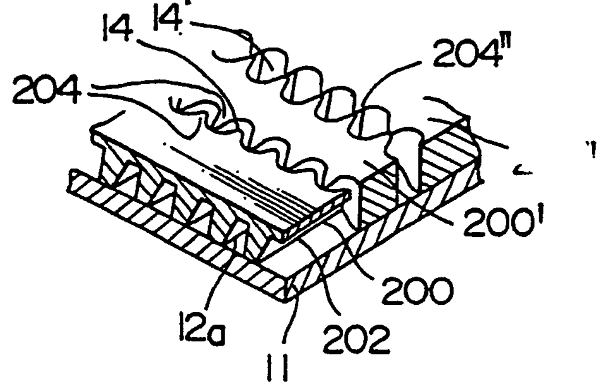


FIG. 18

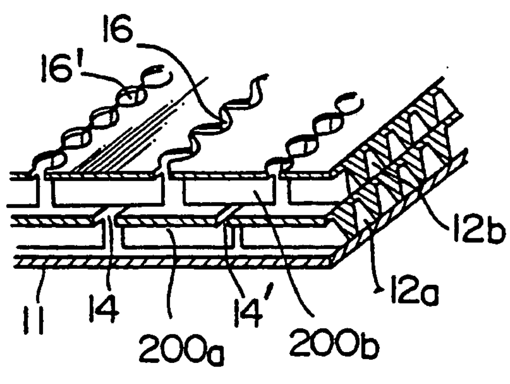


FIG. 19

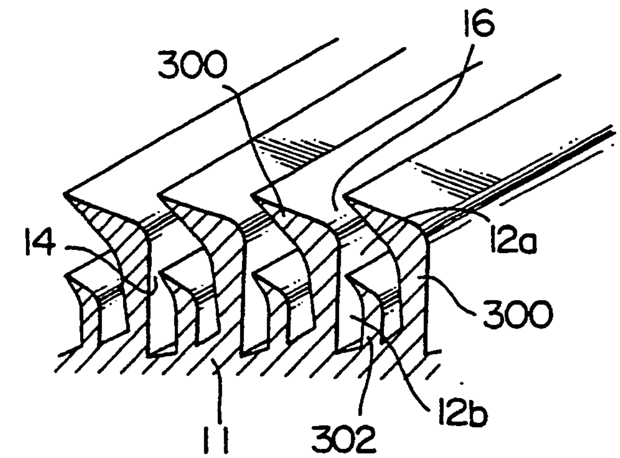


FIG. 20

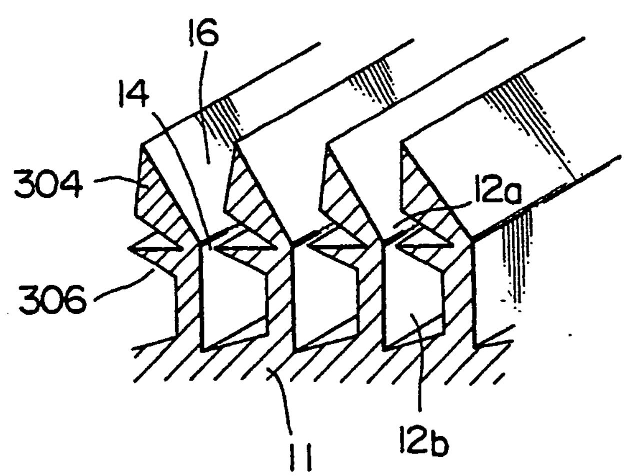
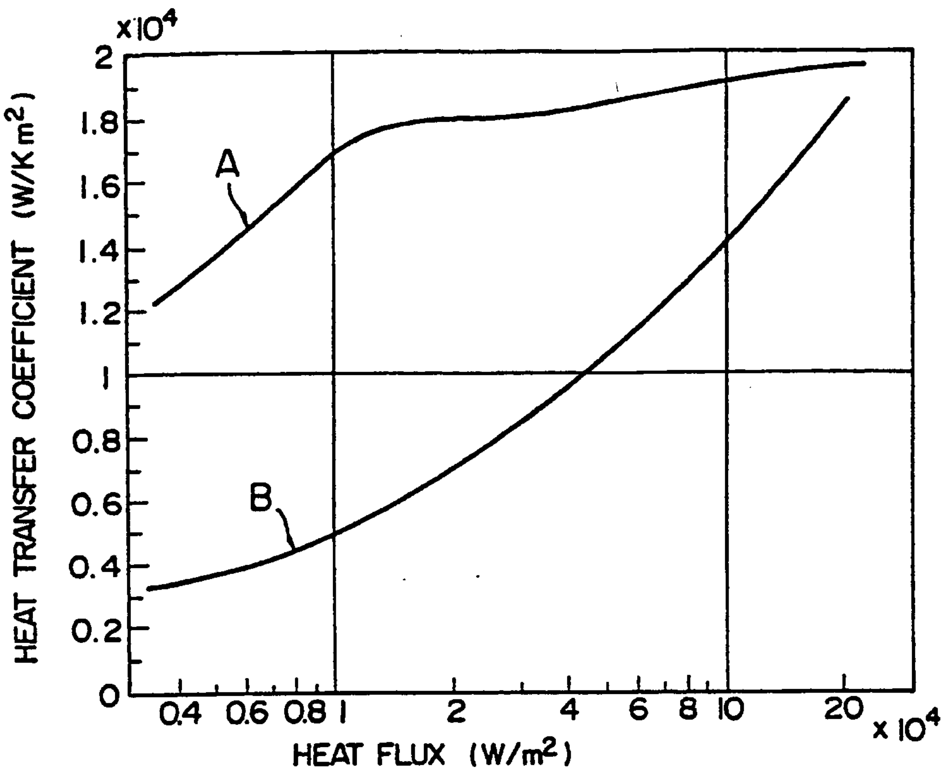


FIG.21


x10^4
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
HEAT TRANSFER COEFFICIENT (W/K m^2)
A
B
0.4 0.6 0.8 1 2 4 6 8 10 20
x 10^4
HEAT FLUX (W/m^2)